

Bunker Hill Mine Water Management Remedial Investigation/ Feasibility Study

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Acronyms and Abbreviations

AAC	acceptable ambient concentration
AHPA	Archaeological and Historic Preservation Act
AMD	acid mine drainage
ARAR	applicable or relevant and appropriate requirement
ARPA	Archaeological Resources Protection Act
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	ambient water quality criteria
BAT	best available technology
BCF	bioaccumulation factor
BCT	best conventional technology
BHSS	Bunker Hill Superfund Site
BLP	Bunker Limited Partnership
BPT	best practicable technology
CAA	Clean Air Act
CDC	Centers for Disease Control
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CIA	Central Impoundment Area
COC	contaminant of concern
CTP	Central Treatment Plant
CWA	Clean Water Act
DEQ	U.S. Department of Environmental Quality
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
ESA	Endangered Species Act



FMEA	failure modes and effects analysis
FR	<i>Federal Register</i>
gpm	gallons per minute
HAZMAT	hazardous materials
HDPE	high-density polyethylene
HDS	high-density sludge
HHRA	human health risk assessment
HMI	human-machine interface
HMTA	Hazardous Materials Transportation Act
IDAPA	Idaho Administrative Procedure Act
IDEQ	Idaho Department of Environmental Quality
IDHW	Idaho Department of Health and Welfare
KT	Kellogg Tunnel
LDR	Land Disposal Restriction
LDS	low-density sludge
LHIP	Lead Health Intervention Program
MCL	maximum contaminant level
msl	mean sea level
MSWLF	municipal solid waste landfill
NAAQS	National Ambient Air Quality Standards
NAGPRA	Native American Graves Protection and Repatriation Act
NBHMC	New Bunker Hill Mining Company
NCP	National Contingency Plan
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRHP	National Registry of Historic Places
NRWQC	National Recommended Water Quality Criteria



NSPS	new source performance standards
NTR	National Toxics Rule
O&M	operation and maintenance
OU	operable unit
PCB	polychlorinated biphenyl
PLC	programmable logic controller
ppm	parts per million
PRP	potentially responsible party
PTM	principal threat material
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
ROW	right-of-way
SAIC	Science Applications International Corporation
SFCdA	South Fork Coeur d'Alene (River)
SSC	site-specific criteria
TBC	to-be-considered (guidance, criteria, and advisories)
TCLP	toxicity characteristic leaching procedure
TMDL	total maximum daily load
TSDF	treatment, storage, and disposal facilities
TSS	total suspended solids
U.S.C.	U.S. Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
WY	water year
WQS	water quality standard



Glossary of Frequently Used Mining Terms

Adit: A horizontal mine opening.

Bedding: Geologic arrangement of sedimentary rocks in strata.

Bedding Plane: The surface that separates one stratum, layer, or bed of stratified rock from another. Individual layers of deposition found within sedimentary rock.

Chute: An inclined channel, as a trough, tube, or shaft, for conveying water, grain, coal, etc., to a lower level.

Conductivity: The conductivity of a solution is a measure of its ability to carry an electrical current, and varies both with the number and type of ions the solution contains.

Crosscut: A horizontal opening driven at right angles to the strike of a vein or rock formation.

Diamond Drill Hole: A small diameter boring whereby a rock core is extracted for the entire length of drilling and used in the exploration for ore.

Drift: An approximately horizontal passageway in underground mining that follows an ore vein.

Filtrate: Water that drains from the raw sludge from onsite disposal beds.

Flotation Tailings: The waste produced from the concentrating process of froth flotation. The mineralized particles will adhere to air bubbles and rise to the top of the slurry. The waste product will sink to the bottom.

Flume: A widely used device for measuring the flow rate in open channels.

Gob: A waste material containing zinc, lead, and iron sulfides.

Grouting: The process of sealing off a water flow in rocks by forcing thin cement slurry, or other chemicals, into the crevices; usually done through a diamond drill hole.

Jig Tailings: The waste product from the concentrating process of jigging. Jigging relied on the specific gravity of the mineralization to separate the ore from the waste. Fines and any lighter ores such as zinc ores (sphalerite) were not effectively recoverable by jigging.

Level: Term used to differentiate the elevations in a mine. For example, the first adit may be called the 100 Level and next adit driven below may be called the 200 Level.

Mill: The plant where the mineralization and waste rock are separated. Mills are also called concentrators. The products of a mill are the concentrate and tailings.

Mine Waste: The rock that comes out of the mine that does not contain enough mineralization to be considered ore. Many times, the waste is non-mineralized from development drifts to reach the ore bodies.



Ore: The material from the mine that contained mineralization with a grade high enough to be profitable.

pH: The negative logarithm of the hydrogen ion concentration.

Portal: The opening of an adit that is at the surface. Quite often, the portal is made of concrete to keep it open.

Raise: A shaft excavated upward from below. An inclined opening from one level to another and used for accessing an ore body.

Shaft: A vertical or sloping passageway leading to the surface used for hoisting or lowering of men or materials as well as hoisting ore or waste.

Stope: Any excavation made in a mine, especially from a steeply inclined vein, to remove the ore that had been rendered accessible by the shafts and drifts.

Tailings Pile: An uncontained pile of waste material from a mill. Generally, the tailings piles are composed of jig tailings and have a particle size of less than 0.5 inch.

Tailings Pond: A contained impoundment of waste material from a mill. The material is generally composed of flotation tailings and is deposited in the pond as a slurry. The pond's purpose was to allow the liquid to be decanted from the slurry.

Upper Country: 9 Level and above.

Yellow Boy: Iron hydroxide ($\text{Fe}(\text{OH})_3$) precipitate that forms as a result of ferric iron (Fe^{3+}) hydroxylation (i.e., ferric iron reacting with H_2O molecules). Iron hydroxide precipitated out of acidic water and accumulated within the flow paths of water within the mine.

Waste Pile: A pile of mine rock that did not meet the minimum grade for ore. May or may not contain mineralization of the type(s) found in ore. Mine waste generally has not been crushed and as such has a particle size that can be up to one foot or greater. The majority of the particles will be less than 1 foot in size.

Winze: An internal shaft within a mine.

Workings: Any mine excavation or operating areas.

Executive Summary

Purpose

This focused Bunker Hill Mine Water Management Remedial Investigation and Feasibility Study (RI/FS) identifies and evaluates remedial alternatives in accordance with the requirements of the National Contingency Plan (NCP). It addresses the discharge of acid mine drainage (AMD) from the Bunker Hill Mine, located within the Bunker Hill Mining and Metallurgical Superfund site near Kellogg, Idaho.

In February 1998, the U.S. Environmental Protection Agency (EPA) and the Idaho Department of Environmental Quality (IDEQ) released a jointly prepared memorandum that identified the need to begin evaluations for long-term mine water management. The RI/FS process was begun in August 1998 in response to the joint IDEQ and EPA memorandum. A work group that includes representatives from both EPA and IDEQ, as well as the current mine owner, have worked together in developing this RI/FS.

Background

AMD Description

The AMD is a result of acid-forming reactions occurring within the mine among water, oxygen, sulfide minerals and bacteria. The majority of the AMD is formed within the Flood-Stanly Ore Body. Yearly spring snowmelt cycles typically increase water infiltration through the ore body, which in turn increases AMD formation. The largest area of water infiltration to the Flood-Stanly Ore Body is the West Fork Milo Creek basin, where all the creek flow is believed to enter the mine in the vicinity of the ore body.

The AMD is acidic and contains dissolved and suspended heavy metals that have demonstrated significant aquatic toxicity. The pH is typically between 2.5 and 3.5, and the constituents of primary concern are heavy metals. Discharge rates from the mine are usually between 1,000 and 2,000 gallons per minute (gpm), but have peaked at over 6,000 gpm during precipitation and snow melt events as a result of surface water infiltration to the mine workings.

Within the mine, the AMD flows through a series of workings and is collected in underground ditches. The lower portions of the mine are flooded, and pumps are used to keep the water level pumped down to about 11 Level. All the AMD converges together on the 9 Level (400 feet higher than 11 Level) of the mine, and is drained through the Kellogg Tunnel and out the Kellogg Tunnel portal, which is the main mine entrance. The Kellogg Tunnel, portal area, portions of the mine yard, underground workings, mineral rights, and much of the land surface above the mine is currently owned by the New Bunker Hill Mining Company, of which Mr. Robert Hopper is president.



At the portal the AMD enters a concrete ditch, passes through a Parshall flume for flow measurement, and then enters a buried pipeline that conveys it to a lined storage pond. A pump station is used to pump the stored AMD to the Central Treatment Plant (CTP). The CTP uses lime neutralization to remove the acidity and to precipitate the metals, which are removed by gravity settling, forming a sludge. The sludge is pumped into an unlined disposal area on top of the Central Impoundment Area (CIA). The treated water is discharged into Bunker Creek, which flows into the South Fork Coeur d'Alene (SFCdA) River. The CTP was constructed by the Bunker Hill Company and has not been significantly upgraded since it started operations in 1974. The CTP is currently operated and owned by the EPA. The EPA is also operating all mine water management systems outside the mine, consisting of the collection channel, pipeline, lined storage pond and pump station, and the sludge disposal area.

Baseline Risk Assessment

The following are the contaminants of concern (COCs) in the mine water identified in the baseline risk assessment:

- For aquatic and terrestrial receptors: aluminum, arsenic, cadmium, copper, iron, lead, manganese, mercury, selenium, silver, and zinc
- For humans: arsenic, cadmium, lead, mercury, and thallium

The AMD contains significant quantities of these COCs, much higher than in treated AMD (current CTP effluent). To put this into perspective (using zinc as an example), a 1-day release of untreated AMD is equivalent to about 1.4 years of existing CTP discharge, and about 5.6 years of discharge if the CTP were updated to achieve current federal and state water quality standards and targets. A prolonged direct release of AMD to Bunker Creek and then to the SFCdA River would result in an acutely toxic shock to the aquatic system, likely resulting in significant mortality of fish and invertebrate species.

Summary of the Problem

The mine water management problem at Bunker Hill stems from the following issues of concern:

- Release of untreated AMD to Bunker Creek results in toxic aquatic conditions in the creek and in the SFCdA River downstream of the confluence.
- The magnitude of the AMD flows, and particularly the high peak flows, results in considerable expense and effort to collect, convey, store and treat the mine water, and to dispose of the sludge.
- AMD discharge from the mine is expected to continue indefinitely. Current technology is unable to stop the formation and discharge of AMD from the mine.
- No long-term plan exists for control and management of the mine water.
- No measures are being taken to further reduce the flow rate and contaminant load of the mine water.



- Equipment at the CTP is reaching the end of its design life or it is inefficient, resulting in high operating costs. Some of the equipment is inoperative, and much of the equipment is approaching 30 years old and needs to be replaced. These conditions increase the likelihood of unplanned CTP shutdowns and the release of untreated AMD.
- The CTP cannot produce treated water that will meet the recently finalized total maximum daily load- (TMDL) based discharge levels and State of Idaho surface water quality criteria.
- The remaining sludge disposal space on the CIA will be filled in approximately 3 to 5 years and additional or replacement space is needed for continued operation of the CTP.

Remedial Action Objectives

The remedial alternatives developed and presented in this RI/FS present options for meeting the following remedial action objectives (RAOs):

- Prevent the release of untreated AMD into Bunker Creek and ultimately into the SFCdA River
- Reduce the concentrations and mass per day of metals discharged into Bunker Creek and ultimately into the SFCdA River
- Achieve the TMDL and Idaho surface water quality criteria
- Upgrade the CTP using more modern and reliable equipment to reduce unplanned shutdowns, to meet the new discharge standards, and to increase efficiency
- Provide additional sludge disposal capacity to enable ongoing operation of the CTP
- Reduce both the overall quantity of AMD generated by the mine, and the peak flows, which are the most difficult to collect and manage
- Reduce long-term AMD management costs
- Reduce the volume of sludge generated at the CTP to reduce long-term disposal costs

Technology Screening and Development of Alternatives

Remedial alternatives were developed by evaluating a variety of technologies for the following six general mine water control components:

- AMD Mitigations/Source Control
- AMD Collection
- AMD Conveyance
- AMD Storage
- AMD Treatment
- Sludge Management

The AMD mitigations/source control component pertains to actions that could reduce the volume or improve the quality of the AMD. AMD collection consists of the method used to



collect water within the mine and transport it to the mine portal. AMD conveyance consists of transporting the AMD from the portal to a treatment facility or into a storage pond. AMD storage addresses the requirement to place AMD in a temporary holding area during those periods when the discharge flow rate from the mine exceeds the capacity of the treatment plant or when the treatment plant is inoperative. AMD treatment consists of changing the chemical characteristics of the mine water such that it is suitable for discharge to Bunker Creek and the SFCdA River. Sludge management consists of dewatering and disposal of sludge generated during the treatment process. Performance monitoring is also a component of each alternative and consists of post-remedial-action monitoring and evaluation of remedy performance.

Remedial Alternatives

The remedial alternatives provide a range of approaches for managing the Bunker Hill mine water. The primary difference between the alternatives is the degree to which AMD mitigations and treatment capacity are implemented. They include a No Further Action alternative (Alternative 1), an alternative consisting of a larger treatment plant but no AMD mitigations (Alternative 2), alternatives that use a phased approach for implementing AMD mitigations and treatment capacity (Alternatives 3 and 4), and one using smaller treatment capacity and all the AMD mitigations carried through technology screening (Alternative 5).

Alternative 1—No Further Action

The NCP requires preparation and development of a “No Action” alternative. The No Action Alternative is a baseline alternative against which other alternatives are judged. For this RI/FS the No Action Alternative consists of performing no “further” actions. No additional remediation activities are undertaken for AMD control, no CTP repairs would be made, and no additional sludge disposal facilities would be constructed when the current CIA disposal area is full, which is expected to be within 3 to 5 years. At this point the CTP would be shut down because it cannot function without sludge disposal. This will result in untreated AMD being discharged into Bunker Creek. When the CTP is shut down, all other mine water management components would also be shut down.

Alternative 2—Treatment Only

Alternative 2, Treatment Only, consists of an updated and improved lime neutralization high-density sludge treatment plant with effluent media filters, but no mitigations for reducing infiltration to the mine and the volume of AMD from the Kellogg Tunnel. The treatment plant is sized to accommodate a peak inflow of 5,000 gpm, large enough to treat all previously recorded Kellogg Tunnel flows except for infrequent high peak flows. These infrequent high flows greater than 5,000 gpm would be stored either in the lined pond or in the mine pool for later extraction and treatment using the existing pump-based diversion and extraction systems. The AMD conveyance pipeline from the portal would be modified to allow direct flow to the CTP. The treatment sludge would be managed using one of the following four options:



Option A: The sludge from the CTP would be pumped into lined sludge disposal beds located on the CIA. In the beds the sludge would dewater by gravity draining and evaporation. The drained water would be collected and re-treated. One 10-year capacity bed would be constructed at a time, and would be capped when full.

Option B: The sludge would be dewatered at the CTP using mechanical equipment and then hauled offsite for disposal in a landfill.

Option C: This option is similar to Option A but the sludge disposal beds would be located on site above the smelter closure area rather than on the CIA.

Option D: In this option the sludge from the CTP would be pumped into one of two sludge drying beds located on the CIA. These would be smaller than the sludge disposal beds, but would dewater the sludge in the same manner. Use of the beds would alternate yearly. Every year the dried sludge from one bed would be removed and trucked to a sludge landfill located above the smelter closure area.

Performance monitoring would be conducted over the life of the remedy, consisting of on-going monitoring at the Kellogg Tunnel portal for AMD flow rate and chemistry, and at the CTP for discharge compliance.

Alternative 3—Phased Mitigations/Treatment

Alternative 3 would phase the implementation of mitigations and treatment plant capacity based on performance monitoring results. The treatment plant would be the same type as for Alternative 2, but would have an initial capacity of 2,500 gpm rather than 5,000 gpm. An initial set of mitigations believed to have the highest potential to be successful would be constructed (West Fork Milo Creek Diversion, Rehabilitate Phil Sheridan raises, and plug in-mine drill holes). Up to 10 years of performance monitoring and evaluation would be conducted to determine if the initial mitigations and treatment plant capacity were sufficient, or if more are needed. A decision process consisting of data analysis, conceptual model refinement, assessment of mitigation effectiveness, and a cost/benefit analysis would be used to evaluate remedy performance, and to select subsequent actions if warranted. Mine water flows in excess of 2,500 gpm would be temporarily stored in the lined pond or in the mine using a new gravity diversion system into the mine pool. A new mine pool extraction system would be installed to reduce the time needed to extract the stored water and to increase reliability. The AMD conveyance pipeline from the portal would be modified to allow direct flow to the CTP. Sludge would be disposed using one of the four sludge options listed in Alternative 2.

Alternative 4—Phased Mitigations/Treatment with Plugging of Near-Stream Workings

All components of Alternative 4 are the same as Alternative 3 except it includes two more initially constructed mitigations. These are plugging the Small Hopes Drift below Mainstem Milo Creek, and plugging the Inez Shaft in Deadwood Gulch below Deadwood Creek. This would reduce or eliminate the possibility of high stream flows eroding direct flow paths into the mine through these areas. Alternative 4 uses the same type of phased approach as Alternative 3 for monitoring performance and determining the need for additional actions.



Alternative 5—Treatment with All Mitigations

Unlike alternatives 3 and 4, Alternative 5 does not use a phased approach. It consists of implementing all the mitigations identified for Alternative 4 plus others, and construction of a treatment plant having a capacity of 2,500 gpm. Given the extensive mitigations implemented, additional treatment capacity is not expected to be necessary. The other components are similar to alternatives 3 and 4, except mitigation performance monitoring is assumed to occur for up to 5 years rather than 10.

Alternatives Evaluation

The alternatives were evaluated against seven of the nine criteria specified by the NCP. Two evaluation criteria, State Acceptance and Community Acceptance, will be evaluated by EPA following receipt of state and public comments at community meetings, agency meetings, and written comments submitted by the state and public in response to the RI/FS. The following are summary evaluations of the other seven criteria. Table ES-1 also provides a summary for each alternative.

Overall Protection of Human Health and the Environment

Alternative 1 does not protect human health and the environment. It results in the direct discharge of untreated AMD to Bunker Creek that endangers humans and results in toxic conditions for aquatic life. Alternatives 2 through 5 all use the same treatment technology. They protect human health and the environment by removing the toxicity associated with AMD to levels that achieve the TMDL discharge allocations for the CTP. Alternatives 3, 4, and 5, however, provide some additional protectiveness over Alternative 2. They include mitigations to reduce the overall volume of AMD, and upgraded diversion and pumping systems that permit more significant in-mine water storage. These additional components reduce the chance of high mine water flows exceeding the downstream capacity of the treatment plant and resulting in a release of untreated AMD to Bunker Creek. Alternative 2, which uses a larger-capacity treatment plant, does not have these additional safeguards. Alternatives 3 and 4 are believed to be somewhat more protective than Alternative 5. They employ a phased approach to implementing mitigations and treatment plant sizing. This approach allows careful consideration of the most effective ways to either reduce mine water flow or optimize treatment plant size. Alternative 5 does not use a phased approach; thus, it has no built-in flexibility to use or benefit from new information gained during installation and operation of initial mitigations, treatment capacity, or both. This lack of flexibility reduces its ability to protect as compared to Alternatives 3 and 4.

All four sludge options are expected to be protective of the community and the environment. Options A, C, and D, the onsite sludge disposal options, provide protection by using lined disposal facilities to prevent leakage to the environment. Fencing and gates would also be used to prevent public exposure to sludge. Option A, disposal in sludge beds located on the CIA, may provide somewhat higher worker protection because sludge handling is minimized. Option B, offsite disposal, provides protection by removing the sludge from the community and transporting it to a secure facility.



Compliance with ARARs

Alternative 1 will not meet chemical-specific ARARs and results in release of untreated AMD to Bunker Creek. All other alternatives are expected to achieve the TMDL-based discharge allocation for the CTP, and be in compliance with most Idaho surface water discharge criteria. Performance monitoring of the upgraded CTP is needed to further assess compliance for Idaho surface water criteria for mercury, selenium, thallium, temperature, dissolved oxygen, and pH. Alternatives 2, 3, 4 and 5 are expected to be in compliance with other chemical-, location-, and action-specific ARARs. All four sludge management options are expected to be in compliance with all ARARs. Therefore, there is no difference between Alternatives 2 through 5 for compliance with ARARs.

Long-Term Effectiveness and Permanence

None of the alternatives will halt the acid-producing reactions occurring within the mine. Acid production and metal release is expected to continue for hundreds or thousands of years unless new technology becomes available and is used to stop the process. The alternatives, however, differ in the degree to which they reduce the quantity of AMD and the magnitude of residual risk remaining from treatment plant sludge.

Alternative 1 takes no measures to reduce the long-term release of AMD from the mine and results in increased long-term human health risk and environmental harm by direct discharge of AMD to Bunker Creek. Alternative 2 also does not reduce the long-term release of AMD from the mine, but uses improved and larger treatment systems to protect human health and the environment. Alternatives 3, 4, and 5 use mitigations to reduce both peak and average AMD flows, which reduces the long-term risk from large flows exceeding treatment capacity compared to Alternative 2. Therefore, these alternatives provide the greatest degree of long-term effectiveness and permanence. The specific effectiveness of the mitigations will not be known until they are constructed and operated for some time; thus, it is possible that the additional mitigations initially implemented in Alternative 5 may not substantially increase overall remedy effectiveness compared to Alternatives 3 and 4.

Alternatives 2 through 5 all require long-term operation, maintenance, and periodic replacement of components. The mitigation facilities of Alternatives 3, 4, and 5 must be inspected and maintained. The mitigation facilities in the West Fork Milo Creek will be difficult to access and clean during winter and spring because of snow accumulation, which increases the probability of clogging by debris and the bypass of water into the mine. However, the potential for this occurring would be minimized during design. AMD collection within the mine is the same for all alternatives. Continual and substantial effort is needed to keep the workings maintained to ensure unimpeded movement of AMD either into storage or out through the Kellogg Tunnel. The in-mine gravity storage system used in Alternatives 3, 4, and 5 will be more reliable than the pumped system of Alternative 2. Alternatives 2 through 5 all use the same treatment processes, which are expected to provide long-term protection by reducing the acid and metals to safe levels. The treatment plants are expected to be reliable and have reasonable backup systems.

Alternatives 2 through 5 all produce the same type of sludge. Compared to Alternative 2, Alternatives 3, 4, and 5 are expected to reduce long-term sludge volumes. These reductions reduce the volume of on- or offsite land required for long-term disposal, and the magnitude



of residual risk remaining from the sludge. All four sludge management options are expected to have adequate and reliable controls to prevent migration of contaminants and public exposure, although Option B (offsite disposal) is expected to produce nearly twice the sludge volumes as the other options. Sufficient sludge disposal space is available onsite for Options A, C, and D, or regionally for Option B. Long-term land use restrictions will be needed for the onsite options (A, C, and D) to prevent disturbance of the capped and closed disposal areas. Option D requires use of trucks to transport the dried sludge from the CIA drying beds to the smelter closure area landfill. About 300 to 600 truckloads would be required over a 1-month period every fall. This volume of truck traffic along McKinley Avenue will provide some community disruption.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 1 results in the existing treatment plant shutting down in 3 to 5 years. This causes an increase in the toxicity, mobility, and volume of AMD contaminants compared to current conditions.

Alternatives 2 through 5 all use the same lime high-density sludge treatment process to remove dissolved metals, and the same type of media filters for removal of suspended metals. The same treatment plant effluent quality is expected from each alternative. The treatment process will remove all of the acidity and will reduce cadmium, lead, and zinc to levels that achieve the TMDLs. The process is expected to significantly reduce the toxicity, mobility, and volume of AMD contaminants by incorporating them into an alkaline sludge. The sludge is classified as a non-hazardous waste. It is expected to pass the toxicity characteristic leaching procedure test, and it is excluded from being characterized as a hazardous waste by the Bevill Amendment to the Resource Conservation and Recovery Act. Alternative 2, however, does not employ source control measures that are expected to reduce the quantity of AMD generated and volume of sludge produced. Alternatives 3, 4, and 5 all employ such measures and thus provide greater volume reductions than Alternative 2. Alternatives 3 and 4 are expected to produce about 10 percent less AMD and sludge than Alternative 2, and Alternative 5 is expected to produce 20 percent less AMD and sludge than Alternative 2.

The treatment process could be reversed if the alkaline sludge is dissolved by contact with sufficient acidity. The onsite options (A, C, and D) use low-permeability liner and cover systems to isolate the sludge from the environment and potential sources of acidity. Long-term land use restrictions are needed to prevent the covered and closed facilities from being disturbed. The offsite option will use appropriate disposal facilities to ensure that the sludge is properly managed.

Short-Term Effectiveness

Alternative 1 increases the risk posed by release of untreated AMD by halting maintenance of existing AMD management systems. Alternatives 2 through 5 are expected to provide about the same short-term protectiveness. The AMD will continue to be collected, stored, and treated using existing systems during construction of new systems. Impacts on the community during construction of Alternatives 2 through 5 are expected to be similar because they all involve AMD pipeline and CTP upgrades, and possibly sludge disposal on-



site. Worker safety is also expected to be about the same because each uses similar construction practices.

Environmental impacts associated with Alternatives 3, 4, and 5 are greater than Alternative 2 because of impacts from mitigation construction. Some of the mitigations require work in stream segments, although some of the segments have been previously disturbed by past mining activities.

Alternatives 2 through 5 will provide protection as soon as they are implemented. The implementation time is similar for each. The phased approach used for Alternatives 3, 4, and 5 may take up to 10 years to complete, but initially implemented remedial actions are expected to provide protection from untreated releases of AMD during the phasing period.

The onsite sludge options (A, C, and D) are expected to have about the same construction impacts on the community because they require similar construction methods and timeframes. Option B, the offsite option, will have minimal community construction impacts because all construction occurs at the CTP.

Implementability

Alternative 1, although technically feasible to implement, may have low administrative feasibility because of the resulting environmental consequences from untreated AMD entering Bunker Creek and the SFCdA River. Alternatives 2 through 5 all have similar implementability. All use standard technologies expected to be reliable given proper operation and maintenance, and all require materials and services available locally or regionally. None of the alternatives prevent the undertaking of additional remedial actions, if necessary. Alternatives 2 through 5 all have the same administrative feasibility, which requires agency coordination similar to that already conducted for other portions of the site. Alternatives 3, 4, and 5 require coordination with landowners to implement mitigations.

Alternatives 2 through 5 require coordination with the mine owner for AMD collection and implementation of in-mine storage. Alternatives 3, 4, and 5 require in-mine monitoring to assess the effectiveness of the mitigations. In-mine monitoring is technically feasible and requires the cooperation of the mine owner for access to underground monitoring locations. In-mine monitoring is not required for Alternative 2.

Onsite sludge options (A, C, and D) would be constructed on federally owned land and would use standard technologies. Therefore, there are no administrative impediments to locating sludge disposal beds in these areas. These areas are also currently under industrial use (waste containment/disposal) and they are anticipated to remain so in the future. There has been some community interest in reuse of the top of the CIA (such as for a golf course) once it has been capped. However, thus far there are no specific plans or agreements in place regarding what type of reuse may be appropriate. Option A, which would be located on top of the CIA, would not preclude community redevelopment of the CIA in the future because the sludge disposal beds would occupy only a limited portion of the CIA (about 10 percent over 30 years), and would be covered and capped when full. Option C will be more difficult to implement than options A and D because of the required sludge pump station and pipeline along McKinley Avenue. Reliance on the pump station and pipeline may make Option C less reliable than options A or D. Option D requires use of public roadways to



TABLE ES-1
Alternatives Evaluation Summary
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Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost ¹ (million \$)
Alternative 1—No Further Action						
Does not protect. Results in discharge of untreated AMD and aquatic toxicity in Bunker Creek and the SFCdA River.	Does not comply with ARARs.	Takes no measures to reduce the long-term release of AMD from the mine and results in increased long-term human health risk and environmental harm by direct discharge of AMD to Bunker Creek.	Results in the existing treatment plant shutting down in 3 to 5 years, increasing the toxicity, mobility, and volume of AMD contaminants compared to current conditions.	Results in increased short-term risks. Never provides protection.	Will likely have low administrative feasibility because of the resulting environmental consequences from untreated AMD entering Bunker Creek and the SFCdA River.	Capital: \$0 Annual O&M: \$6.36 Total NPV: \$6.4
Alternative 2—Treatment Only						
Protects by using storage and a large enhanced treatment plant; however, AMD flows are not reduced. Thus, there is potential for peak flows to exceed storage and treatment capacity.	Expected to comply with most Idaho surface water criteria and attain TMDLs.	Does not halt AMD generation or reduce flows. Although treatment is effective, it is needed indefinitely.	Uses treatment to reduce the toxicity, mobility, and volume of contaminants to acceptable levels. Treatment sludge requires long-term management. Treatment process could be reversed if sludge is dissolved.	Alternatives 2 through 5 are expected to provide about the same short-term protectiveness. The AMD will continue to be collected, stored, and treated using existing systems during construction of new systems.	Readily implementable. Uses existing and available technologies. No administrative difficulties. Adequate sludge storage available on or off-site. Require coordination with the mine owner to implement in-mine storage.	Capital: \$15.5 – \$21.2 Annual O&M: \$2.21 – \$2.90 Total NPV: \$44.0 – \$51.5 Lowest cost alternative (other than Alternative 1)
Alternative 3—Phased Treatment/Mitigations						
Protects by use of mitigations to reduce AMD flows, use of an enhanced in-mine storage system, and use of an enhanced treatment plant. Phased implementation of mitigations and treatment capacity provides flexibility to increase protection if needed, and should provide more overall protectiveness than Alternative 2.	Similar to Alternative 2	Reduces long-term risk compared to Alternative 2 by using mitigations to reduce AMD flows, and an enhanced in-mine storage system. Indefinite treatment is still needed. Reduces sludge volume by about 10 percent compared to Alternative 2.	Uses the same treatment and sludge disposal methods as Alternative 2, but mitigations result in about 10 percent less AMD and sludge. Further reductions will occur if more mitigations are built using the phased approach.	Environmental impacts associated with Alternatives 3, 4, and 5 are greater than Alternative 2 because of impacts from mitigation construction.	Similar to Alternative 2, but additional coordination with the mine owner is required to implement in-mine AMD monitoring. Also requires coordination with landowners to implement mitigations.	Capital: \$20.8 – \$26.4 Annual O&M: \$2.47 – \$3.11 Total NPV: \$52.6 – \$59.4
Alternative 4—Phased Treatment/Mitigations with Plugging of Near-Stream Workings						
Similar to Alternative 3, but initially more protective since two additional mitigations are constructed.	Similar to Alternative 2	Similar to Alternative 3	Similar to Alternative 3	Similar to Alternative 3	Similar to Alternative 3	Capital: \$21.8 – \$27.4 Annual O&M: \$2.47 – \$3.11 Total NPV: \$53.6 – \$60.4
Alternative 5—Treatment with All Mitigations						
Does not use a phased approach and has less flexibility compared to Alternatives 3 and 4. This lack of flexibility reduces its ability to protect as compared to Alternatives 3 and 4.	Similar to Alternative 2	Similar to Alternatives 3 and 4, but since a phased approach is not used, it is possible that the additional mitigations initially implemented may not substantially increase overall remedy effectiveness.	Similar to Alternatives 3 and 4, but mitigations result in about 20 percent less AMD and sludge than Alternative 2.	Similar to Alternative 3	Similar to Alternative 3	Capital: \$27.7 – \$33.2 Annual O&M: \$2.54 – \$3.12 Total NPV: \$60.3 – \$66.4 Highest cost alternative
Sludge Options						
All four sludge options are expected to be protective of the community and the environment.	All four sludge management options are expected to be in compliance with all ARARs.	All four sludge management options are expected to have adequate and reliable controls to prevent migration of contaminants and public exposure. Option D requires about 300 to 600 truckloads of sludge to be hauled each fall along McKinley Avenue from the CIA drying beds to the smelter closure area landfill. Although the trucks would be decontaminated, this volume of truck traffic could be disruptive.	All three onsite options (A, C, and D) use engineering controls or land use restrictions to isolate and protect the sludge from disturbance. The offsite option (B) will use appropriate disposal facilities to ensure that the sludge is properly managed.	The onsite sludge options (A, C, and D) are expected to have about the same construction impacts on the community. Option B, the off-site option, will have minimal community construction impacts because all construction occurs at the CTP.	Onsite sludge options (A, C, and D) would be constructed on federally owned land. Option C more difficult to implement than options A and D because of the sludge pump station and pipeline along McKinley Ave. Sufficient regionally available off-site sludge disposal capacity exists for Option B.	Of the four sludge options, Option B, which uses mechanical dewatering and offsite disposal, is the most costly. Option A, which uses CIA sludge disposal beds, is the least costly. Options C and D have about the same cost.

¹The cost of each alternative depends on which sludge option is selected. 30-year net present values use a 7 percent interest rate to convert future costs to present cost.

AMD = acid mine drainage

SFCdA = South Fork Coeur d’Alene (River)

ARAR = applicable or relevant and appropriate requirement

TMDL = total maximum daily load

transport the sludge from the CIA drying beds to the smelter closure area landfill. There is sufficient regionally available offsite sludge disposal capacity for Option B.

Cost

Table ES-2 presents estimates of the 30-year net present value costs for the alternatives. The 30-year basis is selected merely to compare the early costs of the alternatives. All of the alternatives, except Alternative 1, are expected to have costs beyond 30 years because present information shows that contaminated mine water flows are expected to continue beyond 30 years.

The 30-year net present value costs range from \$6.4 million for Alternative 1 to \$66.4 million for Alternative 5B. Alternatives 3 and 4 are in the middle of the cost range. Other than Alternative 1, Alternative 2 is the least costly, and Alternatives 3, 4, and 5, which all use mitigations, are more costly. Total costs generally go up as more mitigations are implemented. Annual O&M costs also go up as more mitigations are implemented.

Of the four sludge options, Option B, which uses mechanical dewatering and offsite disposal, is the most costly. Option A, which uses CIA sludge drying beds, is the least costly. Options C and D have about the same cost.

TABLE ES-2
Summary of Costs
Bunker Hill Mine Water RI/FS Report

Alternative	Capital Costs (million \$)	Annual O&M Costs ¹ (million \$)	30-Yr NPV ² O&M Costs (million \$)	30-Yr NPV ² Total Costs (million \$)
Alternative 1—No Further Action (4-year NPV)				
1—No Further Action	0	1.88 (Yrs 1-4)	6.4	6.4
Alternative 2—Treatment Only				
2A—with CIA Sludge Disposal Beds	16.6	2.21 (Yrs 1-30)	27.4	44.0
2B—with Mechanical Sludge Dewatering and Offsite Disposal	15.5	2.90 (Yrs 1-30)	36.0	51.5
2C—with Smelter Closure Area Sludge Disposal Beds	21.2	2.23 (Yrs 1-30)	27.7	48.8
2D—with CIA Sludge Drying Beds and Smelter Closure Area Sludge Landfill	20.1	2.31 (Yrs 1-30)	28.7	48.8
Alternative 3—Phased Mitigations/Treatment				
3A—with CIA Sludge Disposal Beds	22.0	2.57 (Yrs 1-10) 2.33 (Yrs 11-30)	30.6	52.6
3B—with Mechanical Sludge Dewatering and Offsite Disposal	20.8	3.21 (Yrs 1-10) 2.97 (Yrs 11-30)	38.6	59.4
3C—with Smelter Closure Area Sludge Disposal Beds	26.4	2.60 (Yrs 1-10) 2.36 (Yrs 11-30)	30.9	57.3
3D—with CIA Sludge Drying Beds and Smelter Closure Area Sludge Landfill	25.0	2.67 (Yrs 1-10) 2.43 (Yrs 11-30)	31.8	56.8
Alternative 4—Phased Mitigations/Treatment with Plugging of Near-Stream Workings				
4A—with CIA Sludge Disposal Beds	23.0	2.57 (Yrs 1-10) 2.33 (Yrs 11-30)	30.6	53.6
4B—with Mechanical Sludge Dewatering and Offsite Disposal	21.8	3.21 (Yrs 1-10) 2.97 (Yrs 11-30)	38.6	60.4
4C—with Smelter Closure Area Sludge Disposal Beds	27.4	2.60 (Yrs 1-10) 2.36 (Yrs 11-30)	30.9	58.3
4D—with CIA Sludge Drying Beds and Smelter Closure Area Sludge Landfill	26.0	2.67 (Yrs 1-10) 2.43 (Yrs 11-30)	31.9	57.9
Alternative 5—Treatment with All Mitigations				
5A—with CIA Sludge Disposal Beds	28.8	2.70 (Yrs 1-5) 2.46 (Yrs 6-30)	31.5	60.3
5B—with Mechanical Sludge Dewatering and Offsite Disposal	27.6	3.28 (Yrs 1-5) 3.04 (Yrs 6-30)	38.7	66.4
5C—with Smelter Closure Area Sludge Disposal Beds	33.2	2.73 (Yrs 1-5) 2.48 (Yrs 6-30)	31.8	65.0
5D—with CIA Sludge Drying Beds and Smelter Closure Area Sludge Landfill	31.4	2.79 (Yrs 1-5) 2.55 (Yrs 6-30)	32.6	64.0

¹The annual O&M costs for Alternatives 3 and 4 is higher the first ten years due to the mitigation performance monitoring assumed to be conducted the first ten years as part of the phased approach. Alternative 5 assumes only 5 years of mitigation performance monitoring.

²The 30-yr Net present Value (NPV) costs are calculated using a 7 percent interest rate.

